CLUB OF BOLOGNA

PROCEEDINGS

of the

23rd Annual Meeting

Bologna, Italy - November 9-10, 2012

on occasion of

EIMA INTERNATIONAL 2012

Conclusions and Recommendations

Session 1

How far is robotics in our future agriculture? ...and what is ready to be transferred in the next years?

Session 2

Life Cycle Assessment in agricultural machinery: a first approach

CONCLUSIONS AND RECOMMENDATIONS

by ***Luigi Bodria*** *(President of the Club of Bologna) and* ***Marco Fiala*** *(Technical Secretary of the Club of Bologna)*

Luigi Bodria, President of the Club of Bologna, **63 experts** from **24 Countries and 2 Representative of an International Organization** took part at the 23rd Meeting of the Club of Bologna, held on 9 and 10 November 2012 in Bologna (Italy), on occasion of EIMA International 2012 and with the sponsorship of FEDERUNACOMA.

There were **7 Key-Note Reports** subdivided into 2 Sessions.

The Session 1 - **How far is robotics in our future agriculture? ...and what is ready to be transferred in the next years?** concerns both a general overview on the current robotics applications in agriculture and the near future transfer of this technology in production processes. Four reports have been presented:

- **Automatic control in agriculture***,* by A. Isidori (University of Rome "La Sapienza", Italy);
- **Autonomous self-propelled units: what is ready today and to come in the near future**, by J. Posselius, C. Foster (CNH);
- **Fleet management and coordination**, by C. Sørensen (Aarhus University, Denmark);
- **Robotic harvesting: lessons from past and future opportunities**, by N. Kondo (Kyoto University Japan);

and two Focus Notes on **Specific industrial applications**:

- **Opportunity of robotics in specialty crop production**, by Q. Zhang (USA);
- **Current and future applications of robotics and automation to agriculture**, by J. Reid (John Deere)

The Session 2 - **Life Cycle Assessment in agricultural machinery: a first approach** considers the applicatione. Two reports have been presented:

- **Principles of Life Cycle Assessment (LCA)**, by V. Bellon-Maurel et Al. (IRSTEA, France);
- **Point of view of agricultural machinery industry**, by P. Pickel, M. Eingner (John Deere);

CONCLUSIONS

Session 1 - How far is robotics in our future agriculture? ...and what is ready to be transferred in the next years?

The first Keynote Report "**Automatic control in agriculture**", presented by A. Isidori from University of Rome "La Sapienza" (Italy) is focused on the great attention in the world of automation in the applications in agricultural machinery.

The author, past-president of the International Federation of Automatic Control (IFAC), which currently includes 52 national member organizations involved in the broad field of Automatic Control, offered a comprehensive and articulated view of the great attention in the field of automation and control to agricultural applications.

Belongs to the agricultural sector one of the first and the most important applications of feedback concepts which was patented in 1927 by Herry Ferguson for the automatic control of hydraulic lift of the three-point hitch in order to achieve constant plowing quality.

Inside IFAC a specific Technical Committee focuses on control in agriculture as a key technology to face main current challenges in agriculture concerning effect of population increase, sustainability and labor shortage.

A recent International Workshop of IFACTC on Agriculture held in in Bulgaria in June 2012 indicated the main highlights of dynamic and control in farming: a Japan five year project (2010-2014) to develop robot farming system, involving Hokkado University and ten industries; advanced technology for high precision navigation system; safety issues for obstacle detection and forces sensors; fully integrated automated fruit picking; system integration of automation in planting and harvesting, wireless command and information transmission.

Promising possible future development concerns Robot-fly powered by independent piezoelectric wings, application of biological modeling and control systems to improve crop and soil quality, multi-agent system for consensus and synchronization in coordinated motion of individual mobile agents.

The second Keynote Report "**Autonomous self-propelled units: what is ready today and to come in the near future**" submitted by John Posselius and presented by R. Morselli from CNH, considers that despite the research in the field of autonomous agricultural machines has been very active in the last 10 years the key enablers is not tied to technology but more linked to legislative act like the bill signed in 2012 approving autonomous vehicles on selected California roads.

Consolidation of different satellite based global positioning systems has allowed multiple levels of location knowledge and steering control. The Wide Area Augmentation System (WAAS) and OmniSTAR have many GRS receivers at known reference position that send a correction message to a geostationary satellite that send the correction to vehicle antenna can offer up to 5-10 cm accuracy. RTK requiring a GPS as base station that can send a correction massage to roving receiver in 12 kilometers radius is highly precise technique that results in 2,5 cm accuracy.

Vision systems are of major importance in the development of auto-guidance of tractors and self-propelled machines. New 3D systems able to provide distance information play an important role in replacing the human ability of depth perception like for forage spot guidance in filling silage wagons.

Telematics and vehicle to vehicle communications is one of the cornerstone for remote control and functional setting of vehicles. All main producers offer wireless telecommunications technologies that allow the ability to view the in-cab display end provide remote support. New Holland, Claas and John Deere all have a control system that helps maximize the combine harvesting efficiency and productivity by automatically adjusting operating parameters in order to optimize the combine process.

Several examples of autonomous applications are mentioned for automated unloading on the go, for both chemical and physical weeds control, as well as drone tractors following tractor with experienced operator.

The third Keynote Report "**Fleet management and coordination**" presented by C. Sørensen from Aarhus University, Denmark underlines the focus on improved resources utilization that needs better process management, automation and control.

Fleet management may be used as the practical tool to improve scheduling, operational efficiency and effectiveness of a fleet of vehicles.

Three different levels of functionality are possible: evasive surveillance and GPS and tracking functions; interactive communication with the operator; comprehensive data acquisition functionalities.

Two different configurations are possible, centralized and decentralized fleet management. The first is a baseline system for planning, scheduling and documentation for mobile field units serving a costumer; a typical example is the coordination of the operations of machine contractor. Contrary to this the decentralized fleet management is viewed as the future system for on-line coordination of mobile units cooperating an accomplishing a specific task within the field as, as example, coordination of combine and grain trailers.

Improving planning tools combined with ICT systems for monitoring and documentation may increase significantly timeless of field operating reducing the unit costs by 20-30% by following a goal-directed planning and monitoring.

The fourth Keynote Report "**Fruit harvesting robots and grading robots**", presented by N. Kondo from Kyoto University, gives an overview of latest developments in robotics.

Although studies on harvesting robots were started since 30 years ago for picking cherry tomato, strawberry, cucumber, orange, apple etc., with a 60-70% success rate or more under greenhouse condition, no harvesting robot has been commercialized yet. The robots are still too slow (one third or less of human operator's speed) and too expensive. In addition robotic operation needs important changing in plant training and cultivation method.

To improve harvesting rate fruit cluster harvesting systems were developed. The merger of the cluster harvesting system with bar positioning of the fruits can enable the realization of very simple and cheaper robots.

On the other hand many type grading robots and non-destructive sensors have been recently developed and applied to many type of fruits. Due to the fact that environmental conditions are suitable for the robots and they can operate much faster than human workers robot system is usually introduced to a cooperative grading facility that can advantage of governmental financial support.

In addition, the fruit grading robot can collect very precise information from handled frits during operation by machine vision and NIR inspection system which can be used for precision agriculture.

The two Focus Notes on " **Specific industrial applications**", both presented by J. Reid from John Deere, give a wide outline on current and future applications of robotics and automation in USA.

From the beginning of "the intelligent equipment age" at the end of the 90s of the last century, there has been an increasing development toward smart machines that are aware of their environment and automatically calibrate, coordinate, sense and optimize their productivity.

Some examples of applications already operating are shown in:

- orchard operations with autonomous tractor for mowing and spraying tasks;
- peat moss harvesting with supervised prototype tractors for autonomous mining;
- multiple autonomous vehicle management in orange grove;
- simple operations like trellis twining or target application of chemicals;
- complicated operations like crops harvesting.

Main challenges are sensor capability, multi-sensory fusion and wide-scale commercialisation and supply but autonomous worksite solutions are feasible and reasonable productivity and convenience.

Session 2 - Life Cycle Assessment in agricultural machinery: a first approach

The first Keynote Report "**Principles of Life Cycle Assessment (LCA)**" presented by V. Bellon-Maurel from IRSTEA, (France), considers both the basic aspects of the LCA methodology and an application to an agricultural equipment (spreaders) as well.

LCA has been standardized through the ISO 14040 series which defines LCA as the "*compilation and evaluation of inputs, outputs and the potential environmental impacts of a product system throughout its life cycle*". The objectives of a LCA can be many, but basically can be restricted "to compile and evaluate the environmental consequences of different options for a fulfilling some function." The strengths of LCA as a framework for evaluating the environmental performances of a product are the following: (i) LCA covers the whole "life" of a product, including also the phases necessary to provide the raw materials necessary for the product building; this prevent from impact transfers from one lifecycle stage to another one; (ii) LCA covers a wide range of impacts, therefore preventing from transfers from one to another impact category to another; (iii) LCA is standardized and the framework must be thoroughly followed which offers good reproducibility of the results; (iv) LCA deals with products described by their functions and not by their nature; therefore two technologies having the same aim (i.e. the same function) but not using the same technology can be compared.

The current ISO standard consists in the four components: (i) scope and goal of the study, functional unit, (ii) inventory of materials and energy flows associated with the stages of the life cycle reported to the functional unit used, (iii) Assessment of potential impacts from energy and material flows identified and (iv) Interpretation of results against targets selected.

As concerns the LCA application on spreader, four application techniques were considered and compared regarding the field application of 100 kg of N from slurry over 1 ha, which is the functional unit. Whereas the transportation phase was included in the system, the storage phase was excluded since it was the same for the four techniques.

The second Keynote Report "**Point of view of agricultural machinery industry**", presented by P. Pickel from John Deere, relates about LCA application on agricultural machinery.

There is a high importance for LCA in the sector of agricultural machines; similar to passenger cars sector, where the political and technical requirements are very high, this sector is already in change. The scarcity of fossil resources and raw materials, as long as the rising energy costs in the last years have brought the industry to a massive rethinking. The reduction of energy consumption and successive use of renewable energy are one of the most important innovation topics in this industry branch.

In order to fulfil the high energy requirements in the near future, extensive concepts, new structures and innovative technical approaches for increasing the total energy efficiency of the machines are needed. Looking at the life cycle of an agricultural machine, LCA helps to identify environmental key factor and cost driver within the use phase where CO_2 emissions (resulting from fuel consumption) are still very high.

RECOMMENDATIONS

Session 1 - How far is robotics in our future agriculture? ...and what is ready to be transferred in the next years?

- ✓ **considering** that despite the high development and great advances in robotics and automation some lacks are still really evident end commercial application are far to come;
- ✓ **underlining** the worldwide interest of scientists and professionals in the field of automatic control toward specific applications in agricultural mechanization;
- ✓ **recalling** that the adoption of appropriate information and automation technologies is a key factor in address the main current challenges in agriculture to meet the growing food needs of the world and to perform it in a sustainable way;
- ✓ **noticing** the potential relevance in automated agriculture of recent advances in System biology and in Control Theory for Multy-Agent (mobile) Systems

the Participants unanimously:

- ✓ **stress** the need to prepare appropriate and reliable safety standards for autonomous driving machines and for robots applicaton;
- ✓ **invite** to consider carefully ethics aspects taking into account that automation and robotics should be developed in harmony with the needs of developing countries and small family farms in general;
- ✓ **identify** as more mature area for robots application animal breeding (milking and feeding), green houses and specialized crops;
- ✓ **acknowledge** that automated operations can play a important role in increasing quality of products and the human safety in dangerous operation;
- ✓ **recommend** to place a high focus on costs analysis of robotics in order to avoid a technological challenge takes over on the economics aspects;
- ✓ **recall** that full exploitation of technological innovation can not be separated by an appropriate updating of the users from universities and research centers;

Session 2 - Life Cycle Assessment in agricultural machinery: a first approach

- ✓ **considering** that LCA is a sophisticated approach but it appears to be a very balanced methodology to quantify - in an integrated outline - the economic, environmental and social performances of products, services or processes;
- ✓ **recalling** that it will be very important to have in the near future powerful tools able to guide the technical and process choices within agricultural sector in terms of general sustainability;
- ✓ **underlining** that LCA approach needs for a lot of information (technical and operative data) and the current data-bases present large lack of information which could be at the moment the cause of improper analysis;
- ✓ **noticing** that results of the first LCA applications on field operations show that the biggest environmental impact come from the use of machines, in particular from fuel consumption and chemicals as well;

the Participants unanimously:

- ✓ **encourage** the researchers to reinforce studies about the application of LCA methodology to the agricultural machinery, processes and services in order – comparing their performances - to reduce environmental effects and to achieve the full sustainability;
- ✓ **confirm** that the crucial factor for the near future years will be to expand data-bases with relevant technical and operative information related to several different region of the world (Developing Countries as well); sensor data from automated agricultural machinery should allow a better understanding of machinery performances;
- ✓ **invite** to concentrate and optimize the research efforts in order to obtain improved and standard data-bases as well as to help manufacturers in design new agricultural machines with high performances in terms of sustainability;
- ✓ **acknowledge** that it is necessary to find and spread uniform calculation-tools for a standard LCA definition as well as it must be study in depth the aspects related to the control and the interpretation of LCA outcomes.

Milan, December 2012